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CoSMoS Coastal Storm Modeling System USGS

Developing a nationally-consistent approach for assessing future coastal hazards

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How big is the climate problem?

- Over 1 billion people are expected to live in the coastal zone by 2050
- Coastal flooding from SLR alone could displace ~200 million people by 2100 with 0.5 to 2 m of SLR
- Hazards assessments are limited to impacts of SLR alone, and do not include waves, storms, coastal change or groundwater impacts

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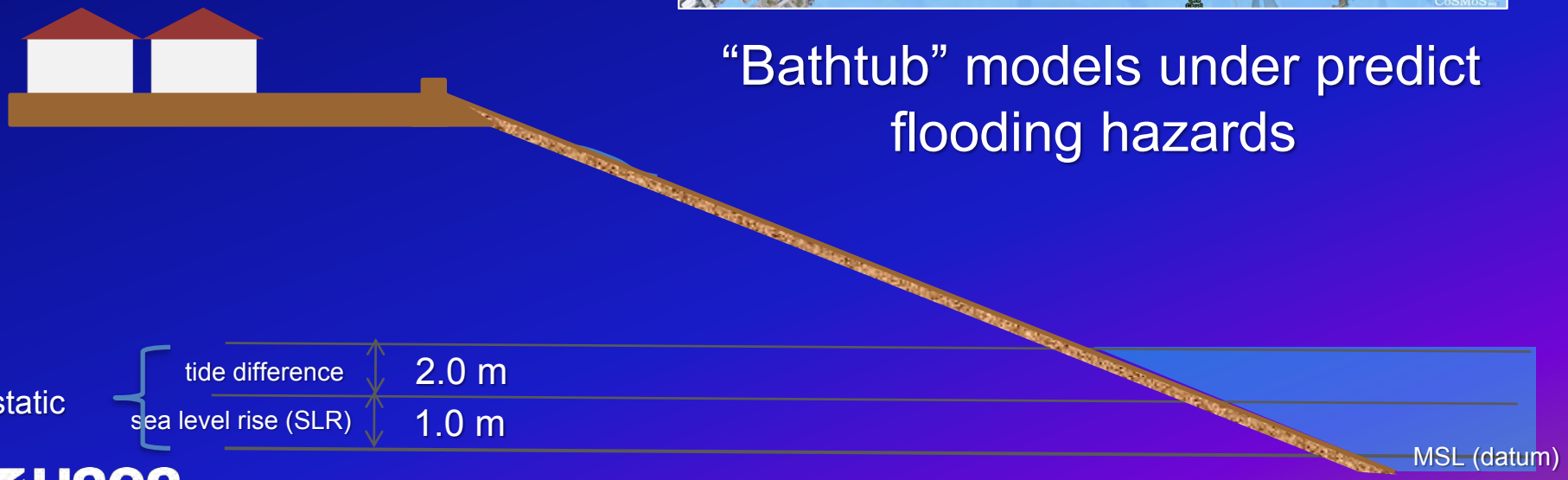
Coastal Vulnerability Approaches

Static

- Passive model, hydrological connectivity
- Tides only
- '1st order screening tool'

"Bathtub" models under predict flooding hazards



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Coastal Vulnerability Approaches

Static

- Passive model, hydrological connectivity
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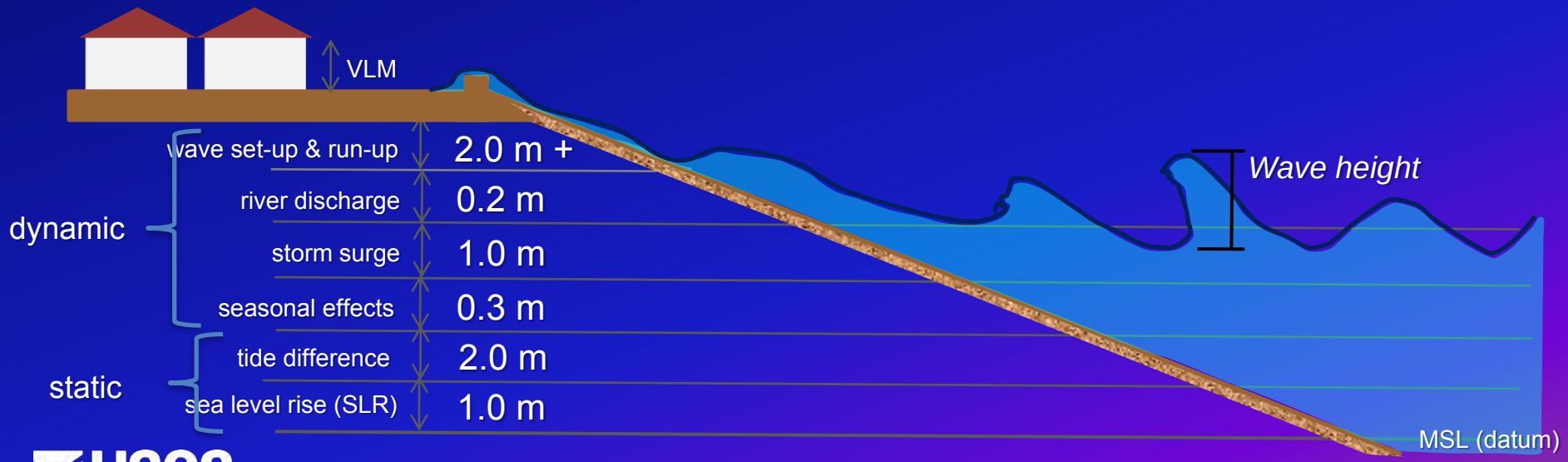
Dynamic: USGS-CoSMoS

- All physics modeled
- Forced by Global Climate Models
- Includes wind, waves, atmospheric pressure, shoreline change
- Range of SLR and storm scenarios



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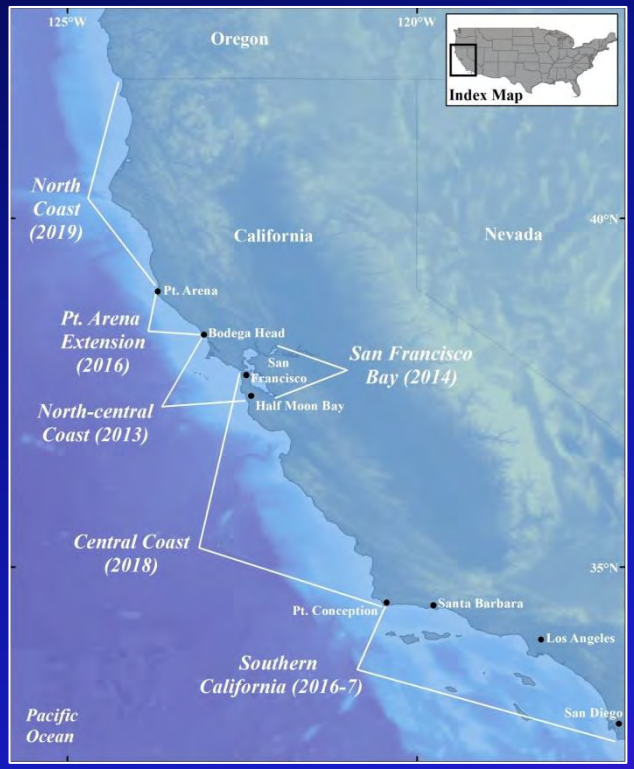
Coastal Storm Modeling System (CoSMoS)

- Physics-based numerical modeling system for assessing coastal hazards due to climate change
- Predicts coastal hazards for the full range of sea level rise (0-5 m) and storm possibilities (up to 100 yr storm) using sophisticated global climate and ocean modeling tools
- Developing coastal vulnerability tools in collaboration with federal, state, and city governments to meet their planning and adaptation needs



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CoSMoS: Major Improvements

- **Identification and selection of multiple storm scenarios for detailed deterministic modeling of local extreme events**
- **Long-term cliff retreat**
- **Long-term shoreline change**
- **Development and integration of projected fluvial discharge rates**
- **Temporal downscaling of daily winds**
- **Assessment of uncertainty, incl. vertical land motion**

Barnard, P.L., Erikson, L.H., Foxgrover, A.C., Finzi Hart, J.A., Limber, P., O'Neill, A.C., van Ormondt, M., Vitousek, S., Wood, N., Hayden, M.K. and Jones, J.M., 2019. Dynamic flood modeling essential to assess the coastal impacts of climate change. *Scientific Reports,* Volume 9, Article #4309, 13 pp., http://dx.doi.org/10.1038/s41598-019-40742-z

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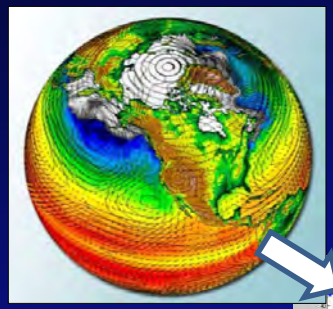
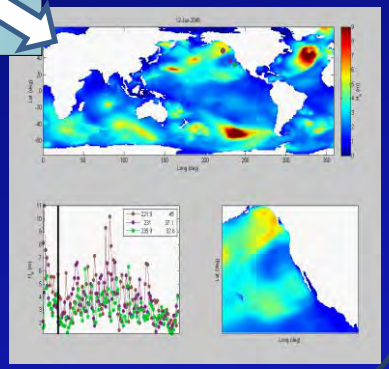
CoSMoS Model Framework

Global

Global climate models (GCMs)



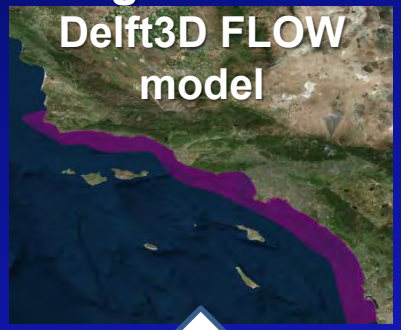
GCM winds

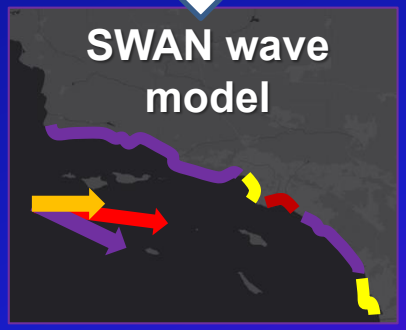


WW3 wave model

Regional

Tides, water levels, and regional forcing

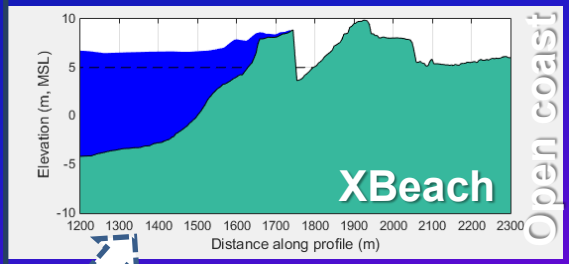




Downscaled winds and SLPs

Local

High resolution hydrodynamics, waves, & fluvial discharge



Long-term cliff recession and shoreline change

results projected onto hi-res DEM

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Web Tool – Flooding

Our Coast, Our Future tool: *www.ourcoastourfuture.org*

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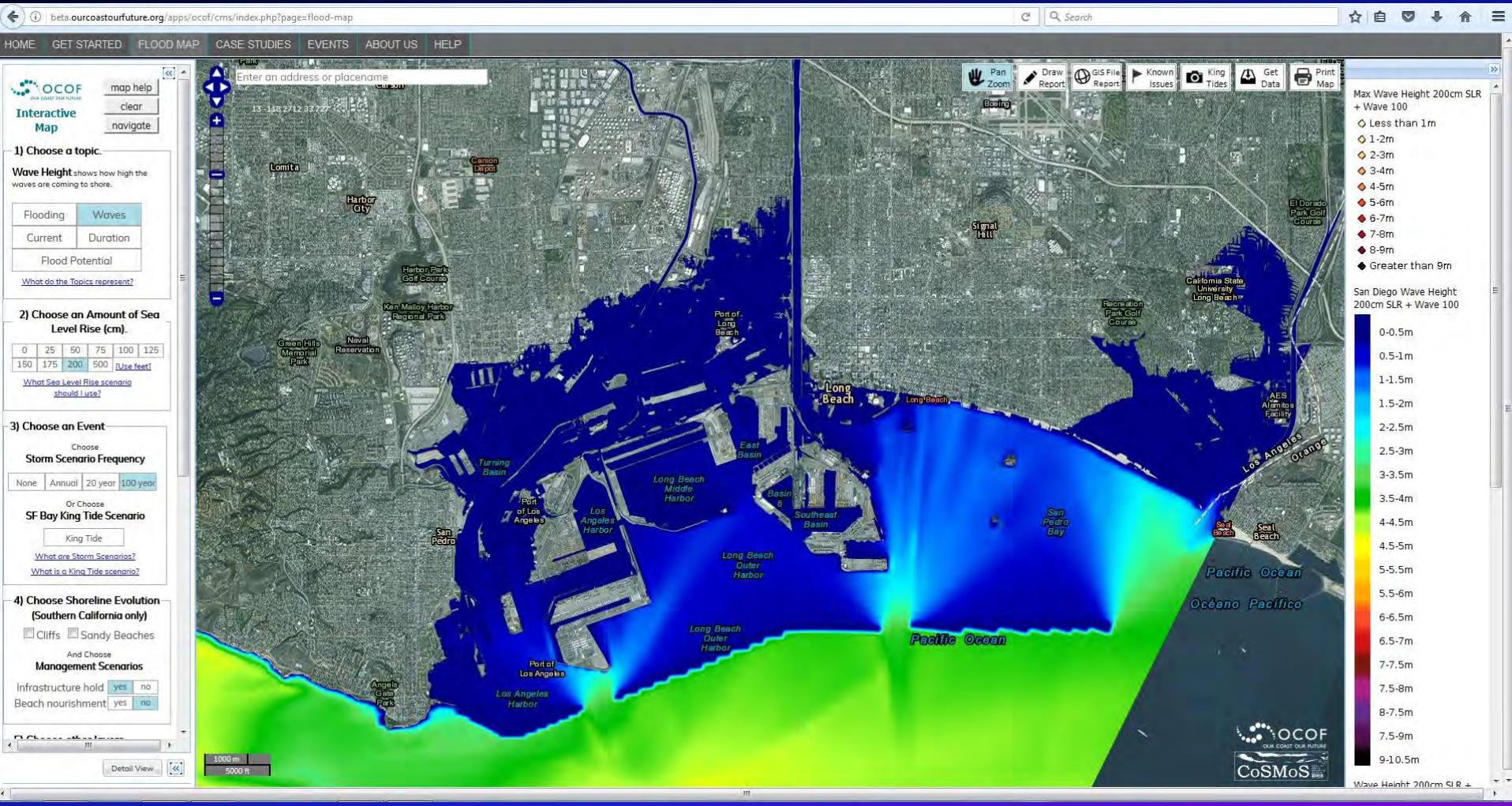
Web Tool - Waves and Currents



Our Coast, Our Future tool: *www.ourcoastourfuture.org*

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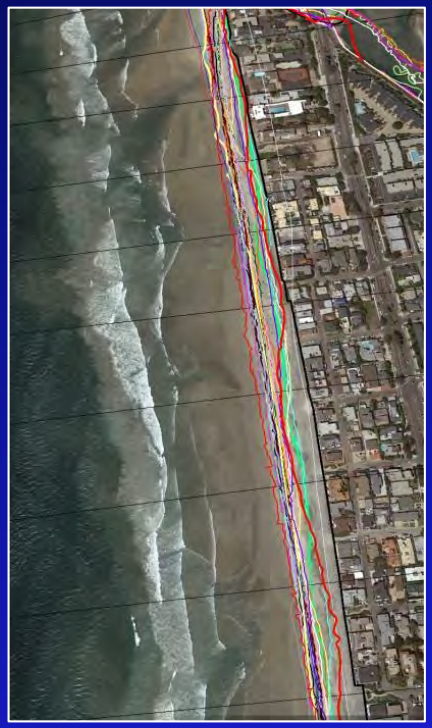
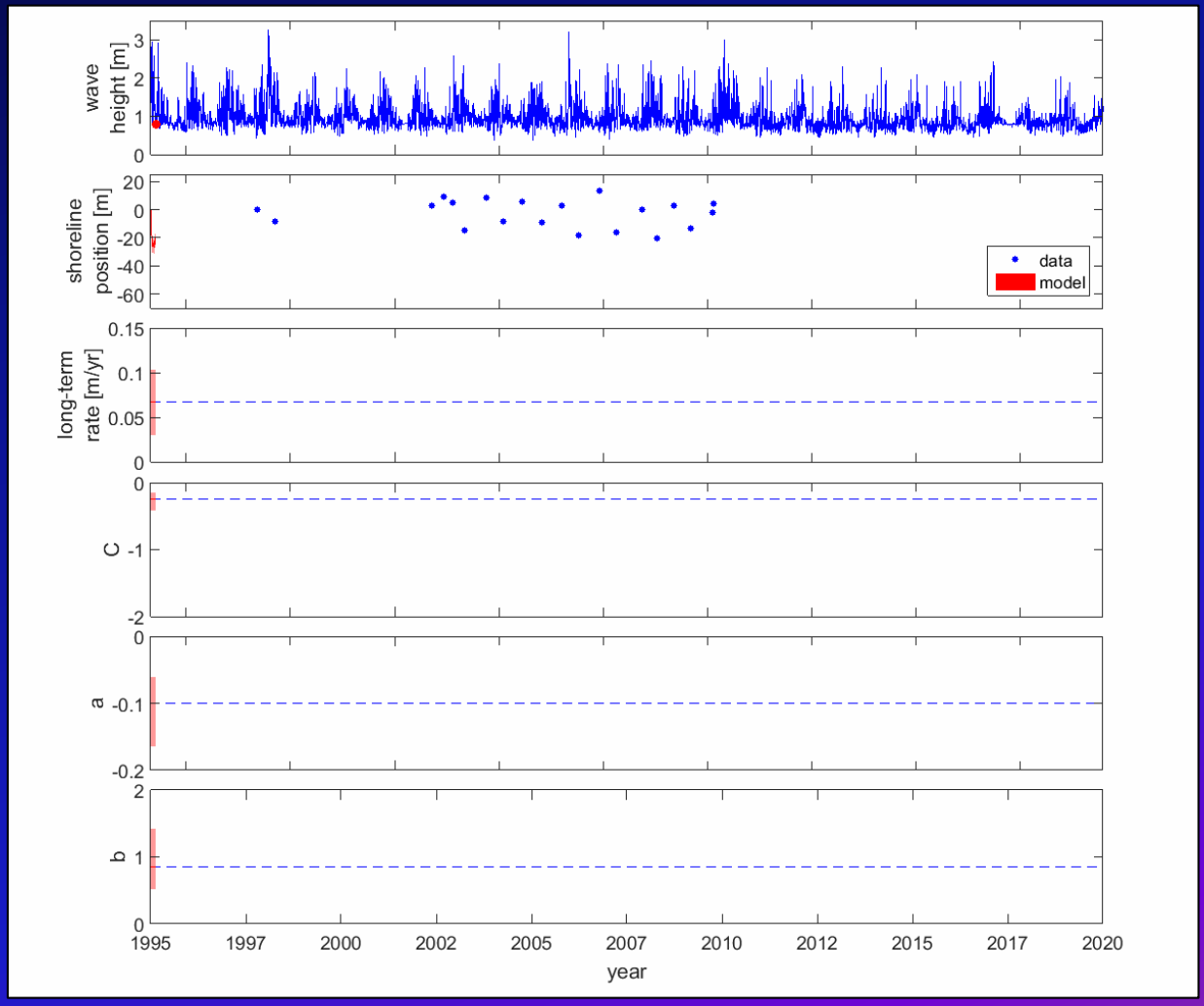
CoSMoS-COAST: Coastal One-line Assimilated Simulation Tool

- We use the ***extended Kalman filter method*** of Long & Plant 2012
  - Auto-tunes model parameters for each transect to best fit the historical shoreline data
- Modeled processes include:
  - Longshore transport
  - Cross-shore transport
  - Effects of sea-level rise
  - Sediment supply by natural & anthropogenic sources

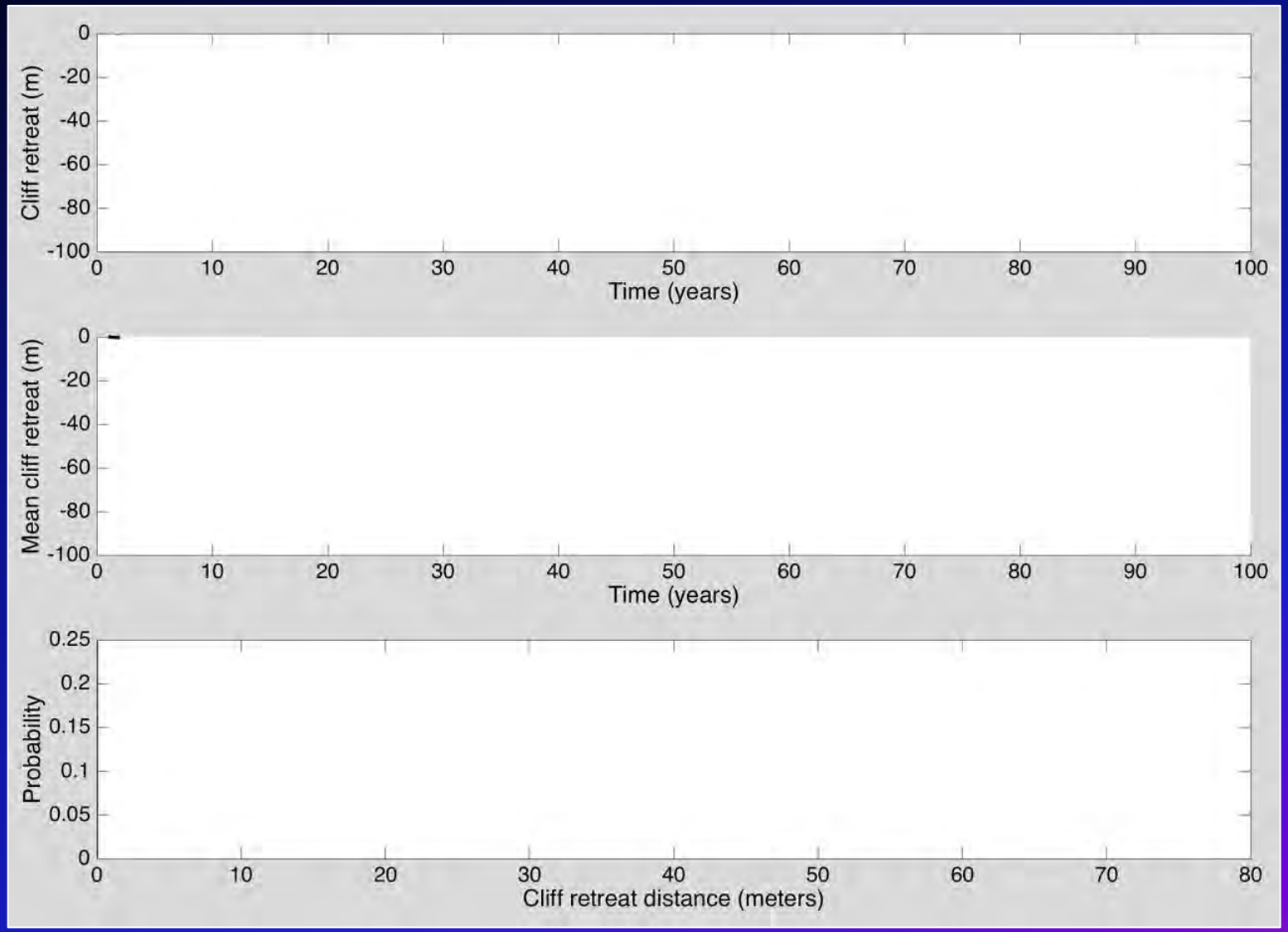




Vitousek, S., Barnard, P.L., Limber, P., Erikson, L.H. and Cole, B., 2017. A model integrating longshore and cross-shore processes for predicting long-term shoreline response to climate change. *Journal of Geophysical Research-Earth Surface*, http://dx.doi.org/10.1002/2016JF004065

Shoreline Projections

Cliff Retreat



Limber, P., Barnard, P.L., Vitousek, S. and Erikson, L.H., 2018. A model ensemble for projecting multi-decadal coastal cliff retreat during the 21st century. *Journal of Geophysical Research-Earth Surface*, http://dx.doi.org/10.1029/2017JF004401

Cliff Retreat Projections

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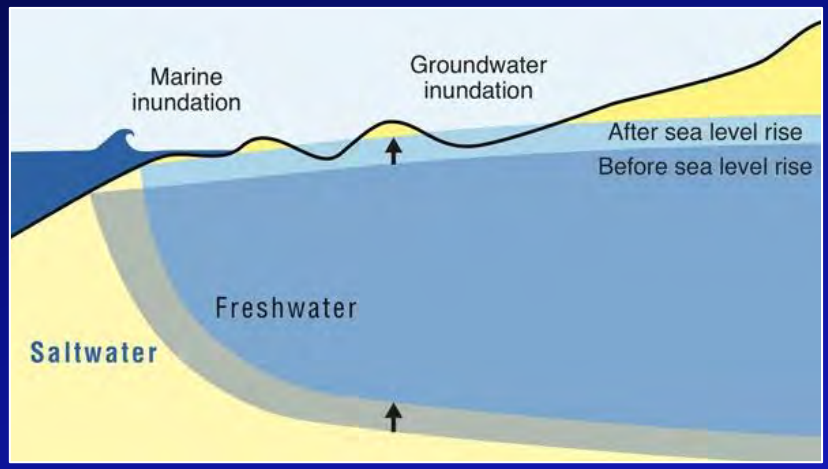
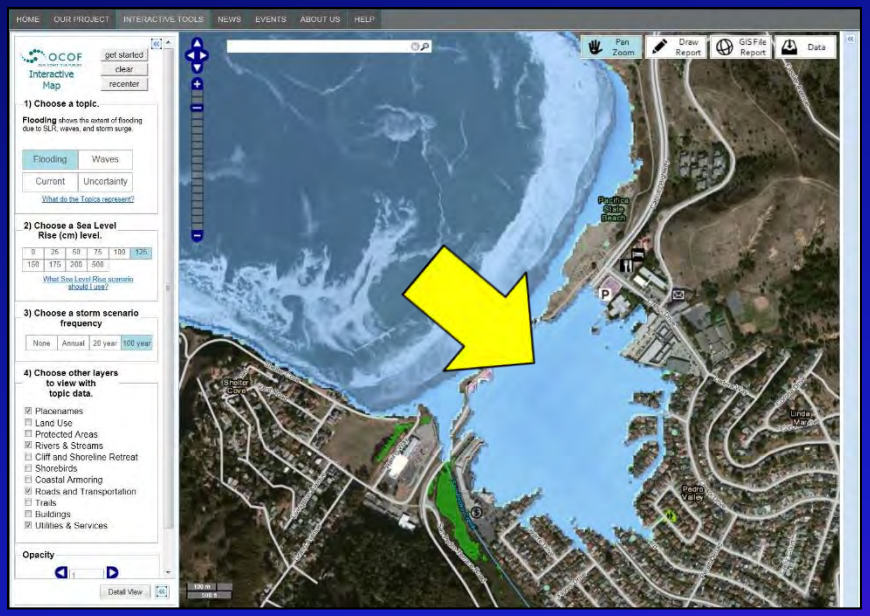
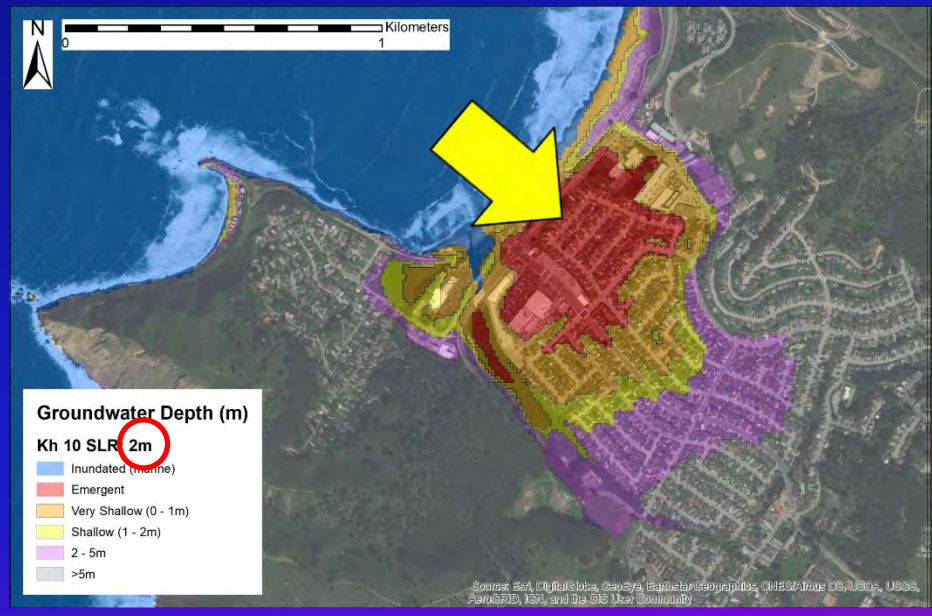
Miami, FL

Coastal Groundwater Response to SLR

- Major issues
  - Emergence/Inundation
  - Shallower coastal groundwater
  - Saltwater intrusion, major hazard for agriculture







Befus, K.M., Barnard, P.L., Hoover, D.J., Finzi Hart, J.A. and Voss, C.I., 2020. Increasing threat of coastal groundwater hazards from sea-level rise in California. *Nature Climate Change*, 16 pp., https://doi.org/10.1038/s41558-020-0874-1

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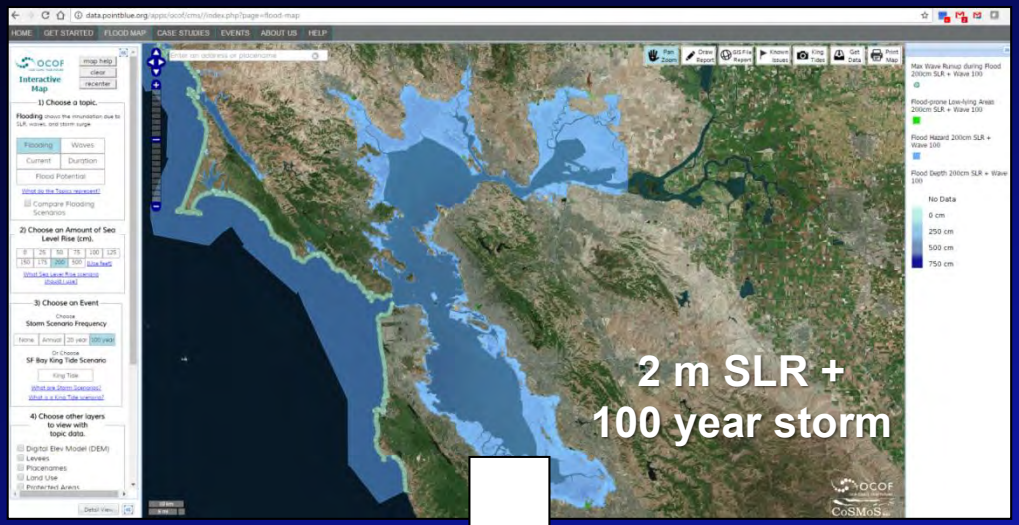
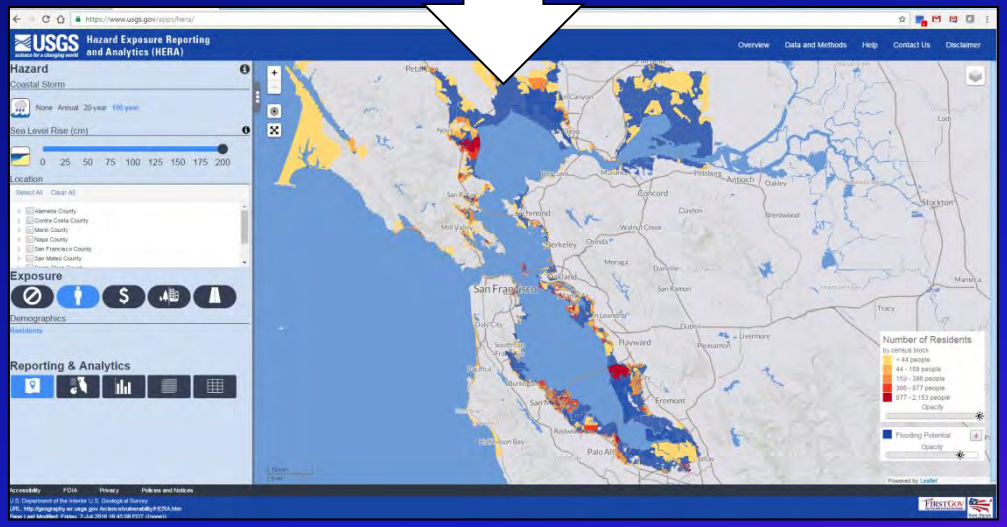
Societal Implications





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California

- 600,000+ residents
- $150 billion in property
- 4,700 km of roads
- 350 critical facilities (e.g., schools, police stations, hospitals)

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Hazards Exposure Reporting and Analytics (HERA)
www.usgs.gov/apps/hera

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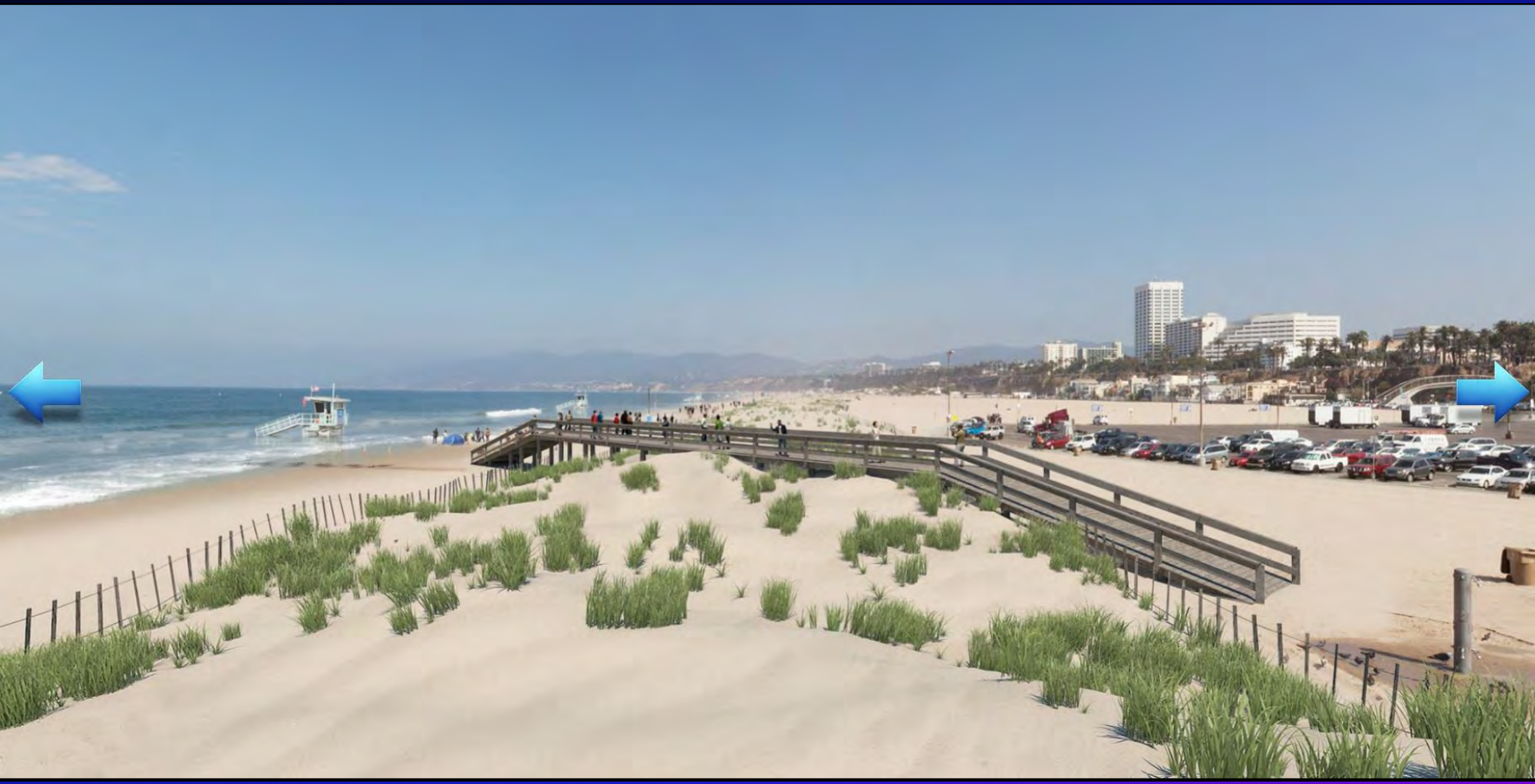
What does the future look like?



Mobile Owl: http://mobileowl.co/samo/

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Sea Grant
University of Southern California

City of
Santa Monica

What does the future look like?

https://vimeo.com/434811381

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Future Coastal Hazards in the Southeast

Objective: Assess the coastal hazards associated with SLR and storms for the 21st century from Virginia Beach to Miami

Key Products:

- 1 m topo-bathy DEM
- Flooding extent, depth and uncertainty
- Long-term beach/dune erosion
- Groundwater hazards
- Socioeconomic exposure

PIs: Patrick Barnard, Li Erikson, Erika Lentz, Davina Passeri

*Project completion March 2022

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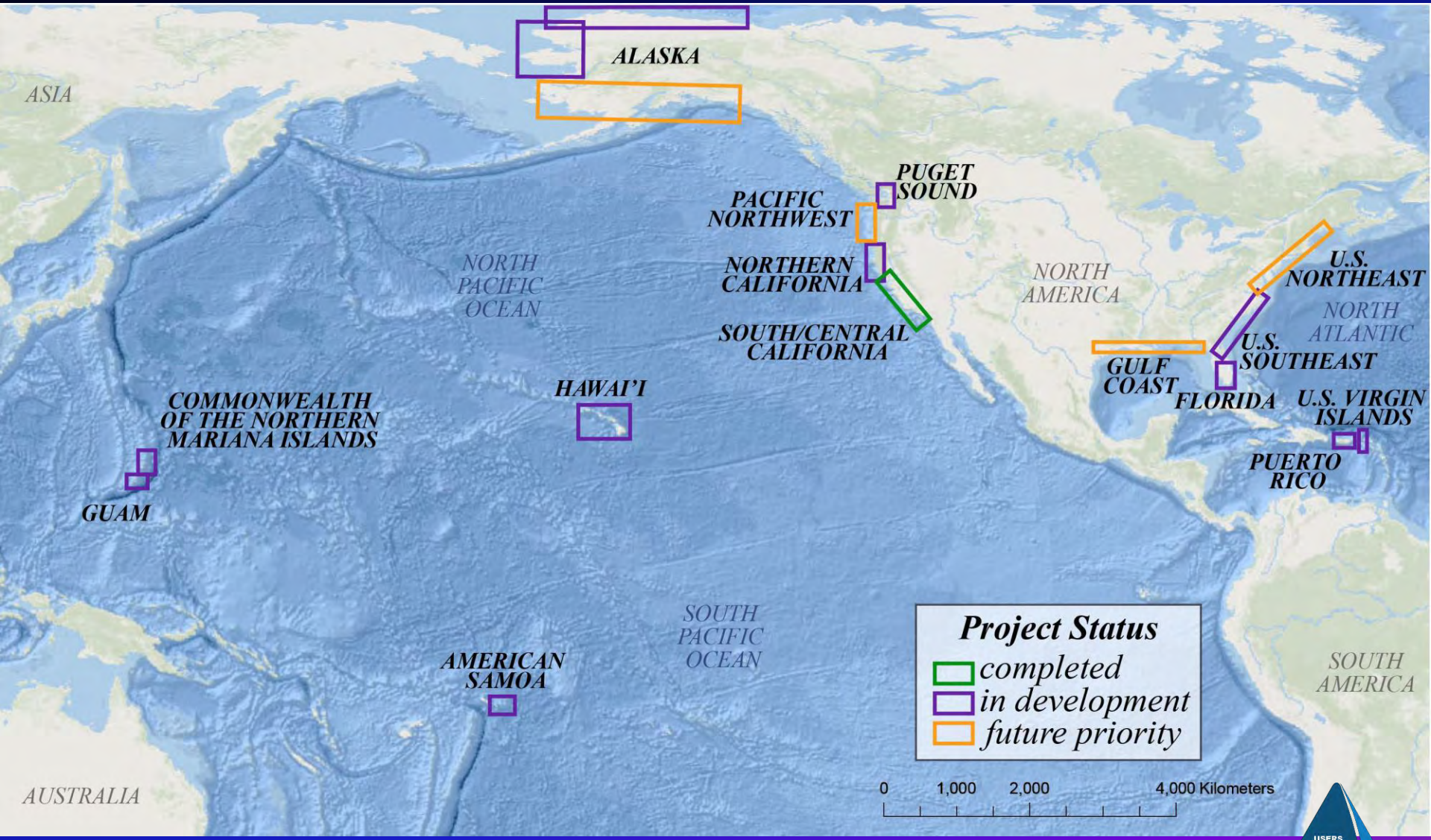
USERS CCH PRODUCTS RESEARCH

National Scope- Future Coastal Hazards



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Future Directions and Research Gaps

- Consistent, national application of coastal hazard models and scenarios with coordination across agencies
- Mine satellite observations, e.g., for shoreline change models
- Direct integration of vertical land motion observations into future flooding projections
- Use of CMIP6 forcing (25 km) to resolve finer scale features, e.g., atmospheric rivers and tropical cyclones
- Translation of physical hazards into ecological and socioeconomic impacts, incl. teleconnections

*For more information, contact Patrick Barnard: *pbarnard@usgs.gov*

USGS CoSMoS data: *www.usgs.gov/cosmos*

Our Coast - Our Future tool: *www.ourcoastourfuture.org*

HERA Tool: www.usgs.gov/apps/hera

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